Elimination of clinical biochemistry laboratory tests through artificial intelligence programs to increase cost-effectiveness

Elimination of laboratory tests through artifcial intelligence program

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Abstract

Aim: The aim of the study was to evaluate the efficacy of software programs such as ALIN IQ, to prevent the regular practice of unnecessary testing in the preanalytical phase, which could save millions of dollars. Material and Method: This study was conducted using data obtained from certain tests using the ALIN IQ software developed by Abbott Core Laboratory. The software implements algorithms defined by the information management system of the hospital to manage laboratory test ordering by clinicians. In the study, three tests—AST, direct bilirubin, and free PSA—were blocked by the software. Instead, the software suggested ALT, total bilirubin, and total PSA tests as preferences when ordered along with other tests sent to the c16000 biochemistry analyzer. Results: In this study, data on numbers of tests (ALT, AST, PSA) run over a one-month period were acquired from ALIN IQ software in a laboratory that runs 2,444,024 tests per year. Findings showed that 11,137 AST, 6,856 direct bilirubin, and 1,340 free PSA tests were ordered unnecessarily over the course of the month, and that avoiding these three tests (AST, direct bilirubin, and free PSA) provided savings of 77.96% from AST, 77.22% from direct bilirubin, and 72.45% from free PSA, corresponding to a projected 231,996 unnecessary tests per year. Discussion: Given the rise of global healthcare costs, reducing laboratory expenditures costing billions of dollars has been discussed in many articles, and different suggestions have been put forward. The present study showed that in addition to the measures set in place in the preanalytical phase, the costs of medical tests could also be reduced through the use of intelligent software programs in the analytical phase.

Keywords

ALIN IQ; Artificial Intelligence Programs; ALT; AST; Total Bilirubin

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Introduction

Health expenditures, including laboratory tests, are gradually increasing worldwide [1], and the cost-effective use of medical laboratories has become a much-debated subject. Ordering a large number of unnecessary tests in the diagnosis and follow up of patients increases costs, and also uses up valuable work-force time, which may lead to failure to notice actual illnesses because of increased workload. This subject has emerged as an important concern in the world, and various solutions have been discussed. The cost of unnecessary testing amounts to billions of dollars in the United States [2]. There are many studies in the literature regarding the regular use of laboratory tests and attempts to reduce laboratory expenditures [3,4]. Studies into changing the habits of clinicians on the use of laboratory tests have followed different strategies, and the information technology (IT) departments of hospitals have come up with instructions such as “Best Practice Advisories” to prompt users to order only rational tests. Monitoring laboratory usage and informing clinicians about laboratory costs decrease the number of test orders, and there have been various studies that support the training of clinicians in good laboratory practices that have played an important role in changing habits [5,6].

In seeking to avoid the increasing number of malpractice lawsuits which can result in substantial indemnity payments, clinicians have tended towards ordering more tests than necessary, so as not to overlook any illnesses [7]. Studies to date have reported on efforts to avoid unnecessary testing in the preanalytical phase through informative training programs, warning messages, and suggestion prompts when tests are being ordered. Recently introduced artificial intelligence software programs have led to the prevention of the use of certain tests in the analytical phase, and such programs have been created for ordering additional, related tests. Commercial kit manufacturers introduced artificial intelligence programs into the market to boost their sales by reducing test orders that do not match up with the kit policies. However, it is possible to use these programs contrary to their manufacturers’ purpose. The use of artificial intelligence programs to prevent the ordering of unnecessary tests in the analytical phase may prevent the ordering of tests that have become a regular practice, thus saving billions of dollars.

Artificial intelligence programs have been used widely to prevent the ordering of related tests in the analytical phase. AST is one such test, which is commonly used to screen for liver diseases; its levels increase correspondingly with ALT levels [8,9]. There are only a very few conditions under which ALT is found to be within normal ranges and where AST is elevated above the normal limits, hemolysis being the most common of those [10]. An AST test order should be rejected in hemolytic samples because if the test is carried out, the result would not be significant and would result in unnecessary costs [11]. Parenteral injections are another factor that affects AST levels, while muscle disease is an important condition in which AST is affected, but ALT is not [12]. Creatine kinase (CK) should also be used in conditions, such as AST, and can be found in places other than the muscle. Hence, orders for AST tests could be canceled in the analytical phase when ALT is found to be normal. Total bilirubin levels increase in liver diseases and bile duct obstruction [13], and this is used in conjunction with direct bilirubin during diagnosis. Direct bilirubin testing makes no sense if total bilirubin is normal. Thus, it would be appropriate to cancel the test order in the analytical phase. Total PSA levels are increased in many prostatic diseases and operations [14] Free PSA testing makes no sense if the total PSA is normal, and so its use can be canceled in the analytical phase. The main focus of the present study is to demonstrate the effectiveness of artificial intelligence programs in the avoidance of tests in the analytical phase.

Material and Method

This study was conducted using data obtained from certain tests using the ALIN IQ software developed by Abbott Core Laboratory, which can implement the algorithms defined by the information management system of the hospital. AST, direct bilirubin, and free PSA were the only blocked tests. The software was set to run ALT, total bilirubin, and total PSA as the preferences when ordered by a clinician along with other tests sent to the c16000 biochemistry analyzer. All AST tests for patients with normal ALT values in the analysis, direct bilirubin tests for patients with normal total bilirubin values, and free PSA tests for patients with normal total PSA values were canceled. AST, direct bilirubin, and free PSA tests were only run if the results of the other tests were outside normal limits. The mean number of AST, ALT, total bilirubin, direct bilirubin, total PSA, and free PSA tests run per month, and AST/ALT, direct bilirubin/total bilirubin, and free PSA/total PSA ratios before and after the use of ALIN IQ software were calculated, and the differences in the number of AST, ALT, total bilirubin, direct bilirubin, total PSA, and free PSA tests and differences in AST/ALT, direct bilirubin/total bilirubin, and free PSA/total PSA ratios before and after the use of ALIN IQ software were calculated, with the magnitude of change recorded separately.

Results

In this study, 14,667 ALT tests and 13,888 AST tests were run in a one-month period before the use of ALIN IQ software. After the ALIN IQ software was deployed, 16,445 ALT tests and 2,751 AST tests were run over a one-month period (Figure 1). Before the use of ALIN IQ software, the AST tests corresponded to 94.68% of all ALT tests. The use of ALIN IQ software eliminated 77.96% of unnecessary AST tests, with the total number of AST tests corresponding to only 16.72% of the ALT tests (Figure 2).

Before the use of ALIN IQ software, 9,243 total bilirubin and 9,184 direct bilirubin tests were run in a one-month period. After the ALIN IQ software was deployed, 10,512 total bilirubin and 2,328 direct bilirubin tests were run over a one-month period (Figure 1). Before the use of ALIN IQ software, direct bilirubin tests corresponded to 99.36% of the total bilirubin tests. The use of ALIN IQ software eliminated 77.22% of unnecessary direct bilirubin tests, with the total number of direct bilirubin tests corresponding to only 22.14% of the total bilirubin tests (Figure 2).

Before the use of ALIN IQ software, 1,870 total PSA and 1,820 free PSA tests were run in a one-month period. After the ALIN IQ software was deployed, 1,930 total PSA tests and 480 free PSA tests were run over a one-month period (Figure 1). Before the use of ALIN IQ software, free PSA tests corresponded to 97.32% of the total PSA tests. The use of ALIN IQ software eliminated 72.45% of unnecessary free PSA tests, with the total number of free PSA tests corresponding to only 24.87% of the total PSA tests (Figure 2).

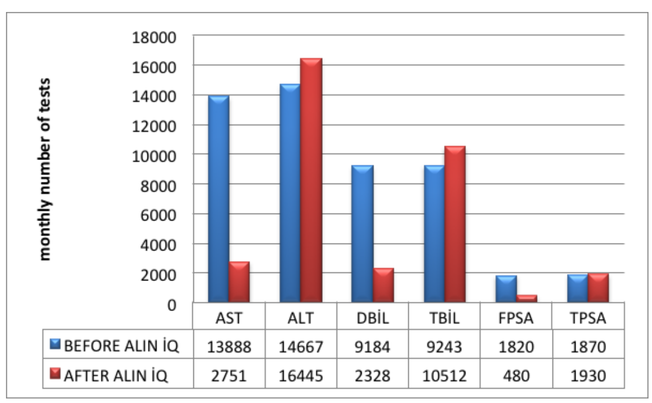

Figure 1. Number of tests ordered before and after the use of ALIN IQ software

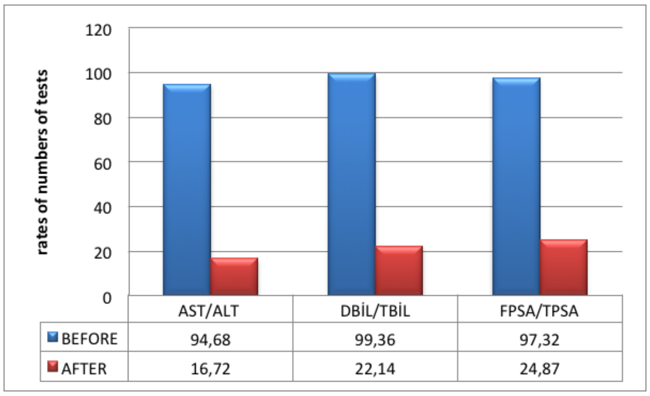

Figure 2. The rates of tests ordered before and after the use of ALIN IQ software

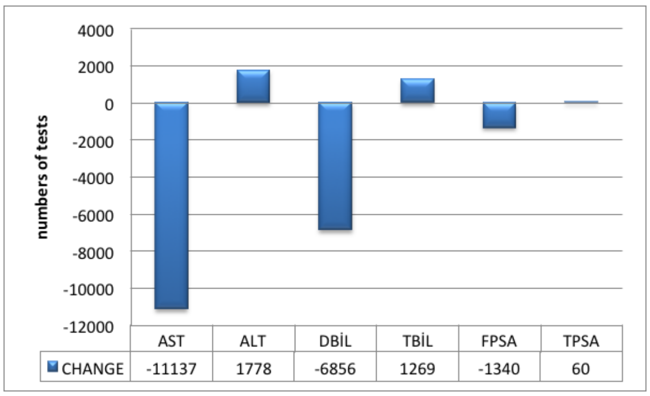

Figure 3. Changes in the number of tests ordered before and after the use of ALIN IQ software

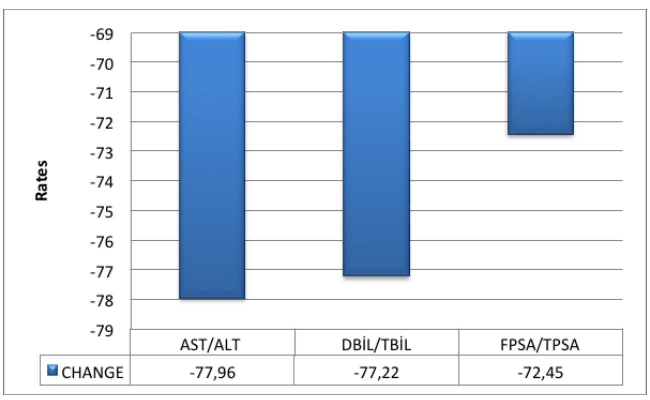

Figure 4. Changes in the rates of tests ordered before and after the use of ALIN IQ software

The software provided savings of 11,137 (77.96%) AST tests, 6,856 (77.22%) direct bilirubin tests, and 1,340 (77.45%) free PSA tests in a one-month period (Figures 3 and 4), corresponding to projected savings of 133,644 AST tests, 82,272 direct bilirubin tests, and 16,080 free PSA tests over the course of a year. In a laboratory that runs 2,444,024 tests per year, ALIN IQ software provided an projected saving of 231,996 tests by blocking the ordering of three unnecessary tests. The amount of savings corresponds to 9.49% of the total number of tests ordered.

Discussion

Inappropriately ordered laboratory tests represent a problem that arises from several possible reasons that have been widely discussed in the literature [15,16]. Given that all physicians undergo medical education in tertiary healthcare facilities at which extensive laboratory workup is performed, defensive medicine, fear of involvement in malpractice cases, lack of laboratory history, lack of sufficient knowledge among doctors, and patient pressure are among the reasons that unnecessary tests are ordered [17,18]. Billions of dollars are spent on unnecessary tests and medical supplies in the United States [19], and various methods have been developed to prevent unnecessary testing costs and to improve test usage to address this global problem. The most commonly employed methods tend to focus on the preanalytical phase [20].

In a meta-analysis by Solomon et al., informing clinicians, auditing laboratory usage, and sharing information on laboratory costs with clinicians were suggested as effective methods to change habits in the use of laboratory services [21]. In another study, the effects of cost education, cost auditing, and the use of clinical cards were compared in their efficiency to reduce the quantity of ordered laboratory tests, and use of clinical cards was found to be the most effective method [22]. In the United States, new health policies support the allocation of resources to the comparative effectiveness studies and to prepare “evidence-based guidelines” to decide which tests or therapies are superior [23]. Education and feedback would be important components in adherence to these guidelines [24].

In a model tested in a private hospital, a hospital information system that allowed clinicians to order tests online was re-arranged to prompt the correct use of laboratory tests. In this model, reminders referred to as “Best Practice Advisories” were integrated into the system, with advice determined by a committee established in the hospital to direct clinicians during the ordering of tests. Warning messages are generated. For example when ordering HBsAg, the warning, “Please make sure that the patient did not have a hepatitis vaccine shot in the last two weeks” is given, or in the case of a repeated test, the warning, “You are ordering the same test for the second time” is given [25].

Test ordering habits could be changed through training of clinicians [26]. As part of this training, ways to limit the ordering of certain tests and to change test ordering habits have been suggested [27]. In another study that compared methods of informing clinicians, no feedback was provided to one group of clinicians; feedback was provided to a second group regarding their laboratory usage habits; for a third group, a document regarding the cost-effective use of laboratory testing was provided; while a fourth group received feedback about their own laboratory usage habits and the cost-effective use of the laboratory. The highest cost reduction, amounting to 42%, was noted in the fourth group [28].

A “Computerized Clinician Order Login Screen” has been used to alert clinicians regarding the implementation of targeted strategies. Daily routine laboratory test order panels prepared by the clinicians (routine biochemistry, calcium/phosphor/magnesium, and complete blood count) constitute the majority of test orders in inpatient cases. The system requires an explanation from the clinician when making repeat test orders within a three-day period. Thus, test orders could be limited. In one study, the use of this method was found to reduce test orders by 24% in inpatient cases [29].

Modifications to the login screens used by clinicians are another method that has been investigated. In one study, redundant tests with limited clinical efficacy were removed from the quick order screen, making the ordering of such tests more difficult. For example, lactate dehydrogenase (LDH) is found to be abnormal in many conditions and it provides similar results to creatine kinase and transaminases tests. Removal of the LDH test from the order entry screen via a quick scan has resulted in an approximate 50% reduction in unnecessary LDH orders for inpatients [30].

Controlling ordering frequency is another proposed method. In one study of intensive care unit patients, the ordering of complete blood counts, biochemistries, and coagulation tests more than once in a 24-hour period was blocked, and this was reported to reduce order numbers without causing any side effects or affecting discharge times [31].

Relentless strategies, such as blocking laboratory tests at the time of order, are undesirable because they restrict the clinicians' freedom and may lead to concerns that conditions may not be diagnosed in time. Blocking tests that are related to each other in the analytical phase would not raise any objections because it would not restrict the clinicians' freedom. A literature review showed that preanalytical variables and measures have been the subject of previous studies. However, to our knowledge, there are no studies to date that aimed to reduce the number of unnecessary tests ordered in the analytical phase. In this regard, this research is the first study of its kind in the literature.

In this study, for the first time in the literature, an attempt was made to avoid unnecessary tests being ordered in the analytical phase by defining algorithms described in the method sections for ALIN IQ software, developed by Abbott Core Laboratory, for use in the clinical biochemistry laboratory of the Harran University Training and Research Hospital. In proportion to the total number of test orders, ALIN IQ achieved a 77.96% reduction in AST tests, a 77.22% reduction in direct bilirubin tests, and a 72.45% reduction in free PSA tests (Figure 4). In a laboratory that runs 2,444,024 tests per year, the ALIN IQ software provided projected savings of 231,996 tests by blocking the ordering of three different and unnecessary tests. The savings corresponds to 9.49% of the total number of tests ordered. ALIN IQ and similar software programs may provide more savings in hospitals with a high patient load. Furthermore, these software programs, in addition to providing cost savings, can also calculate daily test averages and will prompt users if systematic errors are detected. Also, they can detect any calibration shifts that may occur during the day. The Delta check feature also permits the detection of significant differences between previous and current test results in patients in the validation phase, while the automatic validation of normal test results may reduce waiting times.

Conclusion

This study has shown that software programs can provide significant savings in routine clinical biochemistry laboratories. Algorithms that aim to eliminate unnecessary tests can be used for hepatitis markers, expensive immunoassays, and PCR tests, in addition to biochemistry. ALIN IQ and similar smart software programs do not depend on the device brand and can be adapted to any analyzer capable of the data transfer. The use of such software programs in diagnostic laboratories with high workloads can be considered a cost-effective approach given that their costs are lower than the savings they achieve.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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